

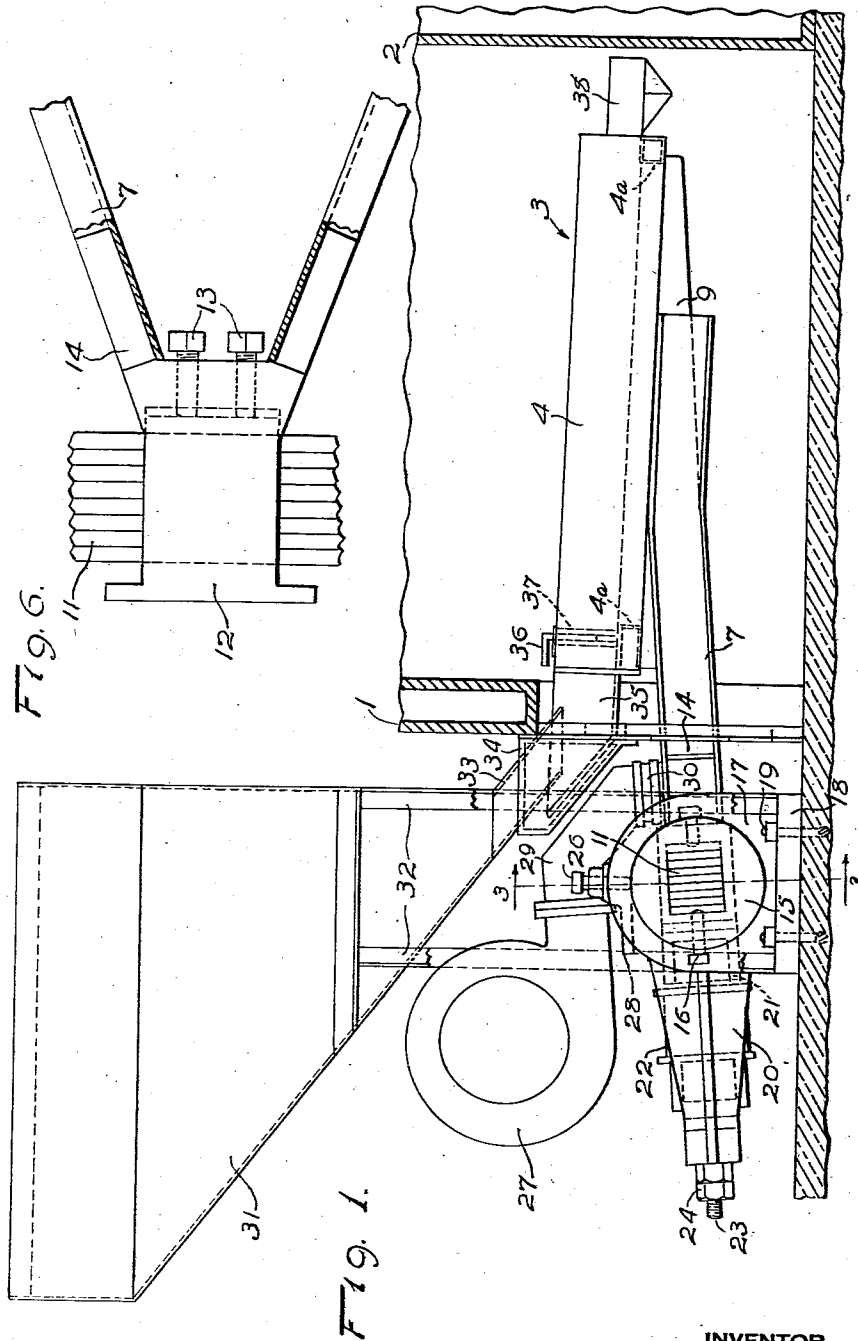
June 7, 1938.

E. O. MARTY

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STOKER AND METHOD OF BURNING FUEL

Original Filed Dec. 21, 1931 4 Sheets-Sheet 1



INVENTOR
E. O. Marty
BY *J. D. Murray*
ATTORNEY

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E. O. MARTY

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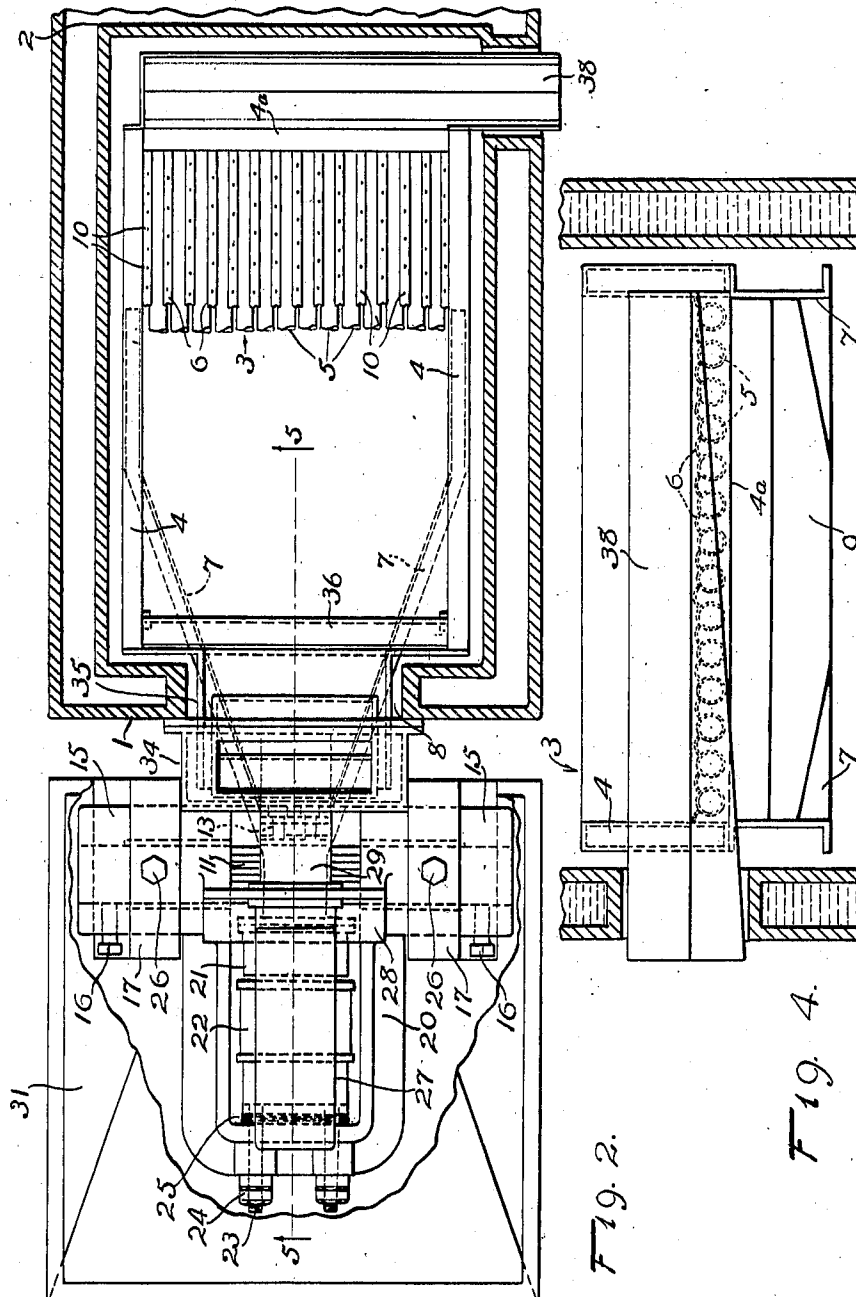


Fig. 2.

Fig. 4.

INVENTOR
E. O. Marty
BY *J. D. Murray*
ATTORNEY

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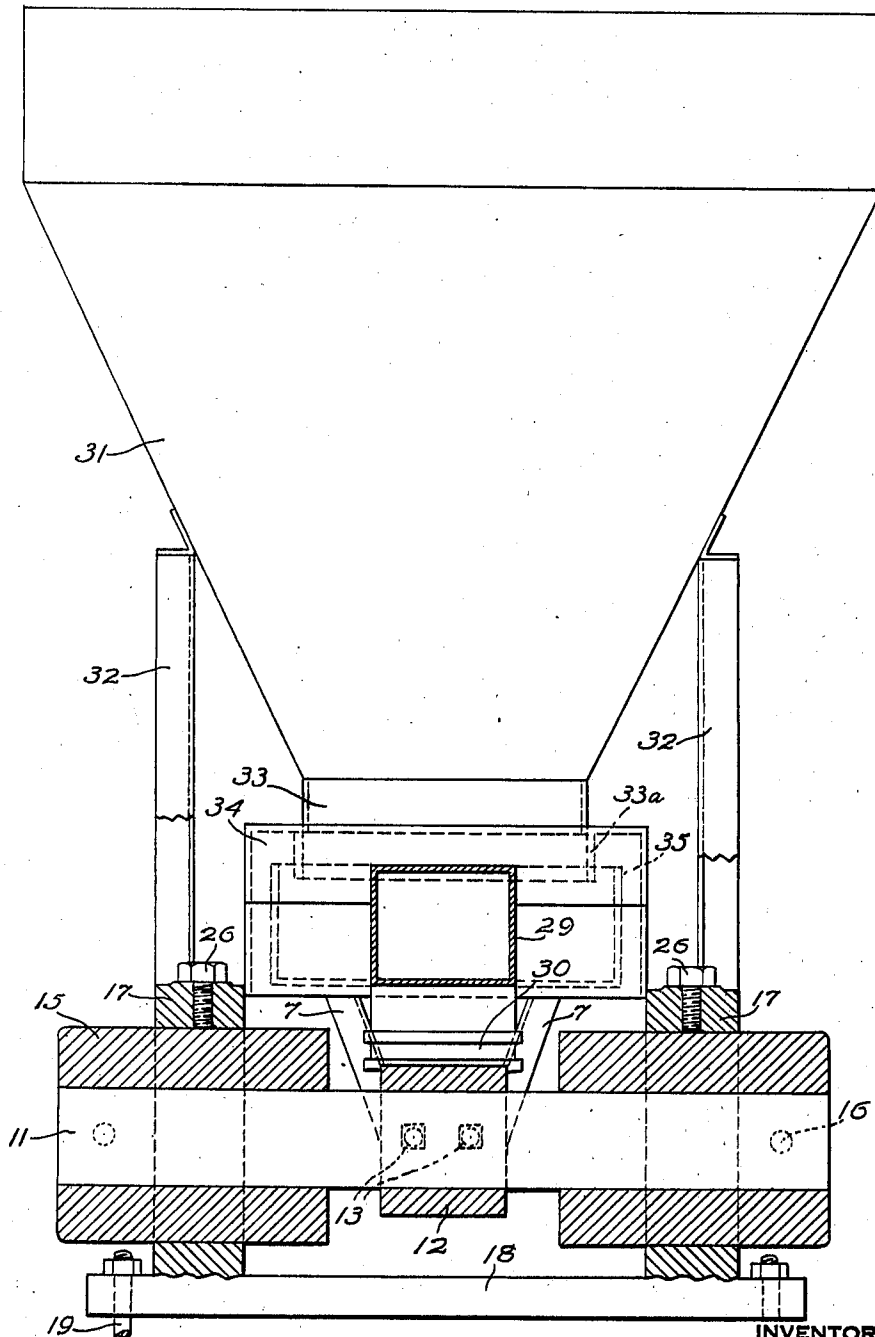


Fig. 3.

INVENTOR
E. O. Marty
BY *J. D. Murray*
ATTORNEY

June 7, 1938.

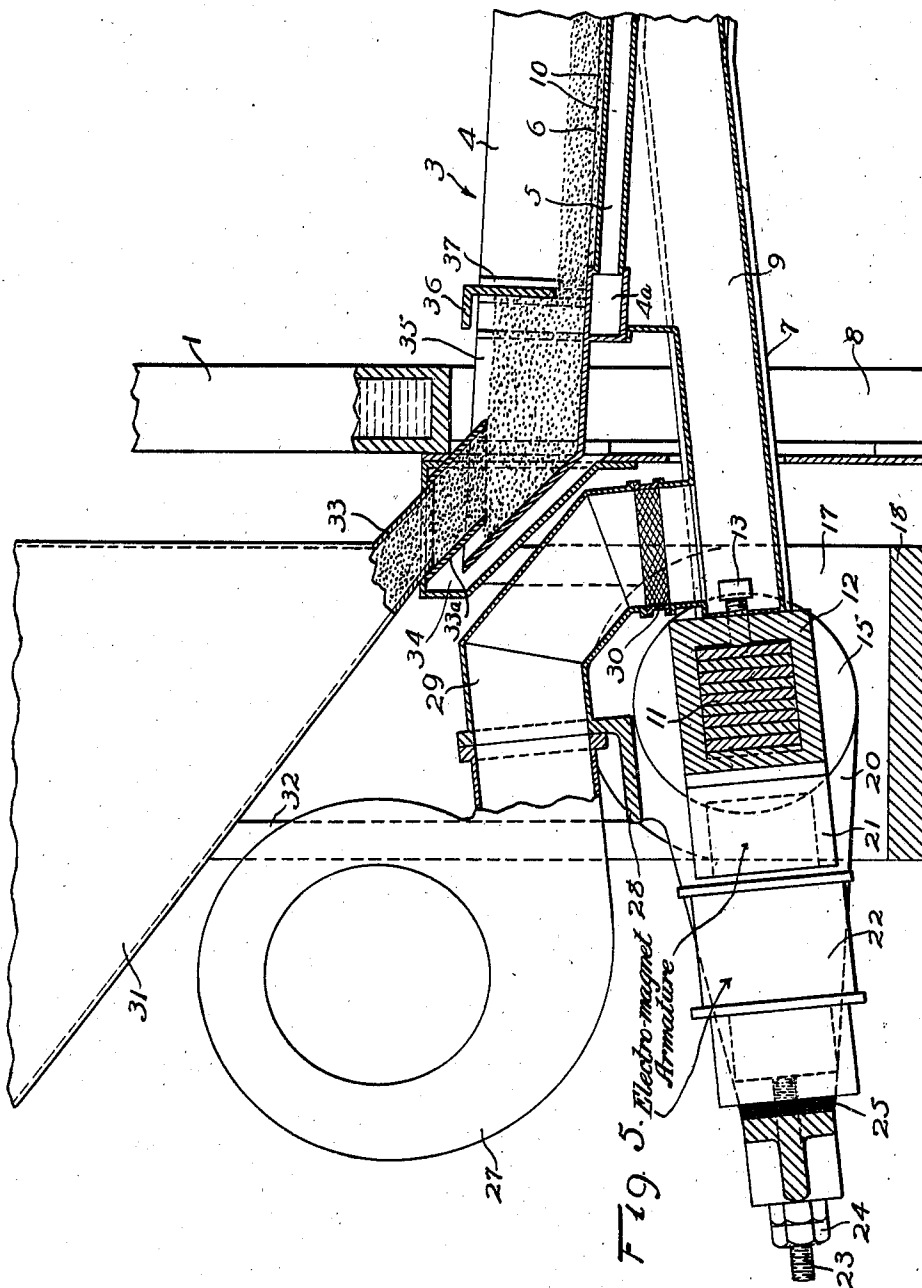
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UNITED STATES PATENT OFFICE

2,119,554

STOKER AND METHOD OF BURNING FUEL

Edgar O. Marty, Pottsville, Pa.

Application December 21, 1931, Serial No. 582,309
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40 Claims. (Cl. 110—38)

This invention relates to stokers and particularly to stokers which effect an even spread of fuel and a gradual advance of the fuel bed upon a grate, and preferably down an inclination thereof, by an agitation of the grate. The invention further relates to methods of burning fuel.

An object of the invention is to vibrate a furnace grate at a much greater rate and through a lesser amplitude than has heretofore been done, thereby deriving numerous advantages herein-after explained in detail.

Another object is to employ a highly simplified electro-magnetic actuator to produce such vibration, and to control the vibration rate by a simple electrical apparatus, and thereby regulate the rate of advance of the fuel bed.

A further object is to adapt a vibratory grate to be readily adjusted at selective inclinations and thereby further (and more permanently) control the rate of fuel advance.

Still further objects are to pivotally mount an inclined furnace grate for the purpose of varying its inclination, to retain the grate in selective pivotal positions, and to locate its pivotal support in an exterior relation to the furnace, such as to afford ready access thereto for adjustment purposes, to safeguard such mounting and the adjustment means from the furnace heat, and to facilitate installation of the grate and its control mechanism as a replacement unit.

Still another object is to connect the grate vibrating means in a unitary relation to the grate, and to maintain such relation in all positions of pivotal adjustment of the grate.

It is also an object to employ an improved method for delivering fuel to a grate, advancing fuel and ashes toward a discharge end of the grate and removing ashes from said discharge end.

These and various other objects the invention attains by construction hereinafter described, and illustrated in the accompanying drawings, wherein:

Fig. 1 is a view in side elevation of the improved stoker, sectionally showing the portion of a furnace to which the stoker is applied.

Fig. 2 is a top plan view of the same, showing the furnace walls in section and breaking away certain of the stoker parts.

Fig. 3 is a front view of the stoker and lower portion of the furnace, said view being taken in part on section line 3—3 of Fig. 1.

Fig. 4 is a rear view of the grate, sectionally showing the lower portions of the furnace side walls.

Fig. 5 is a vertical sectional elevation of a construction mounting the grate, said section being taken upon the line 5—5 of Fig. 2.

Fig. 6 is a fragmentary plan view, partially in section of a provision for mounting a pair of grate-carrying arms on a bar spring.

In these views, the reference characters 1 and 2 designate respectively the front and rear walls of a common type of domestic furnace, to which the invention is applied in the illustrated embodiment thereof. Between said walls is installed a grate 3, which may be part of the original installation, or may replace the original furnace grate. The grate 3 is preferably gradually declined from its front to its rear end, to facilitate a gradual rearward fuel travel, responsive to vibration of the grate. Said grate may be of any suitable construction, and as illustrated, comprises a hollow rectangular frame 4, including end headers 4a, a series of spaced tubes 5 extending lengthwise of said frame and establishing communication between said headers, and a series of metallic tuyère strips 6 rigidly carried by said tubes and bridging the spaces therebetween.

To support said grate there is employed, preferably, a pair of arms formed by channel beams 7 having end portions welded or otherwise rigidly attached to the sides of the frame 4, centrally therebeneath. Said beams extend convergently forward from the grate at a downward inclination, establishing them at an acute angle to the grate length, and preferably pass through the usual front wall opening 8, giving access to the ash pit.

Beneath the grate 3 and between the arms 7 is rigidly mounted an air box 9 substantially coextensive in its main area with the grate and having a portion projecting between said arms forwardly and exteriorly of the furnace, said portion progressively reducing in width toward its front end. As will presently appear, provision is made for continuously forcing air into the box 9 during stoker operation, such air discharging upwardly through the fuel bed through suitable vents 10 in the strips 6.

At their forward ends, the arms 7 rigidly engage a support which is preferably sufficiently flexible to afford said arms and the grate carried thereby a longitudinal vibratory movement of small amplitude. Thus, as illustrated, said arms are carried by the central portion of a laminated bar spring 11 mounted in horizontal parallelism and exterior proximity to the front wall of the furnace, as best appears in Figs. 2 and 5. The

illustrated means for attaching said arms to said spring consists of a rectangular sleeve 12 fitted on the midportion of said spring and rigidly secured thereto by set screws 13, said sleeve integrally carrying a pair of divergent extensions 14 engaged in the channels of the arms 7 and welded or otherwise rigidly connected to the latter. The end portions of the spring 11 are snugly fitted in suitable rectangular openings centrally formed in a pair of cylindrical trunnions 15, which carry clamping screws 16 restraining said spring from longitudinal shifting. Said trunnions are rotatively carried in a pair of standards 17 rising from the end portions of a heavy bed plate 18. Foundation bolts 19 or the like rigidly attach said bed plate and standards to the floor of the furnace room.

The trunnions 15 preferably are formed as coaxial lateral projections from a U-shaped yoke 20, constituting a mounting for an actuator inducing vibration of the arms 7 and grate. While such an actuator may have various forms, it is preferred to employ an electro-magnetic device comprising an armature 21 rigidly carried by the sleeve 12, and an electro-magnet 22 coacting with said armature and rigidly carried by the yoke 20 within its central opening. Said electro-magnet is clamped against the forward end of said yoke by a pair of bolts 23 in conjunction with nuts 24 exteriorly seating against said end, and the most effective spaced relation between the electro-magnet and armature may be established by positioning a suitable number of shims 25 between the magnet and yoke.

The grate and its vibration actuator are adjustable as a unit about the axis established by the trunnions 15, for the purpose of selectively varying the pitch or angle of declination of the grate. Said grate and its actuator are positioned at opposite sides of said axis, and are held in selective positions of their unitary adjustment by set screws 26 carried by the standards 17 and bearing on said trunnions.

For delivering air under suitable pressure to the box 9, and thence to the described grate, there is employed a blower 27 discharging into that end of the air box which projects forwardly beyond the furnace. Preferably, said blower is rigidly carried by a bracket 28 extending between and upstanding from the trunnions 15 and rigidly connecting the latter. The outlet duct 29 of said blower connects through a flexible collar 30 with the front end of said air box, thus rendering the fan independent of vibration of the air box and grate.

For delivering fuel to the upper end of the grate, a suitable hopper 31 is positioned in front of the furnace, above the blower and vibration actuator. Said hopper surmounts suitable steel uprights 32 rising from the ends of the bed plate 18, weight of the hopper and its contents being thus utilized to resist vibration of the bed plate. At its lower end, the hopper carries a rearwardly inclined discharge tube 33 which fits snugly into a correspondingly inclined fuel chute 33a rigidly carried by and within an air-sealing chamber 34 mounted upon the furnace wall 1. Said chamber covers an opening in said wall through which projects a fuel delivery extension 35, rigidly carried by and forwardly projecting from the grate. Said extension has a width considerably less than that of the grate, being thus adapted to pass through said wall opening, as best appears in Fig. 2. The chute 33a is adapted to deliver fuel from the hopper 31 to the

extension 35, the latter extending beneath said chute within the chamber 34, as is clearly shown in Fig. 5. Said extension has ample clearance from the walls of the chamber 34 and from the chute 33a to allow it to freely participate in vibration of the grate. Thus the chamber 34 and its chute 33a serve to deliver fuel to the grate from a point exterior to the furnace while maintaining a substantial air seal at the point of delivery, and without interference with free vibration of the grate.

If desired, the depth of the fuel at its point of discharge to the main area of the grate may be selectively regulated by provision of a vertically adjustable gate 36 upon the forward grate extremity. This gate may consist simply of a sheet metal plate extending from side to side of the grate and retained in vertically slotted guides 37 carried by the side members of the frame 4. The top portion of said plate will preferably be bent at a right angle to the plate proper, to facilitate manipulation. It is evident that the space interval formed between the fuel-supporting surface and the lower edge of the gate 36 will control the delivery depth of fuel.

Upon the rear or lower end of the grate, it is preferred to mount an ash chute 38, the bottom of which lies slightly below the fuel-carrying surface of the grate and said bottom being inclined slightly transversely of the grate. Thus said chute may receive the ashes discharging from the grate and agitation of the grate will gradually carry such ashes to the lower end of said chute. As illustrated, said end passes through the furnace wall, to discharge the ashes at one side of the furnace.

In operation of the described stoker, the magnet 22 may be energized by an alternating current of practically any commercial frequency. This frequency will establish the rate of periodic attraction of the armature 21, and consequently the vibration rate of the arms 7 and the grate which they carry. Each response of the armature to the magnet, of course, involves a slight flexure of the spring bar 11 from its normal rectilinear form, the bar and armature springing away from the magnet during its low energization periods.

Departing widely from prior practice, it is proposed in the present construction to vibrate the grate through an amplitude which may, in some installations, be of barely perceptible magnitude, and which will, preferably, in no case exceed one quarter of an inch. The practical range of grate vibration probably lies between four thousand and three hundred oscillations per minute, preferably approaching the higher limit. If, however, it be found feasible to induce oscillations at any rate exceeding four thousand per minute, it is believed such oscillations will be effective to induce the desired gradual fuel advance and to promote highly efficient combustion. Where the vibration rate within the specified range is relatively high, the amplitude will, of course, be correspondingly low, and vice versa. Alternating current, as now commonly available, has frequencies of sixty or twenty-five cycles per second. Where such currents are employed to energize the electro-magnet 22, the oscillation rate of the grate would ordinarily be seventy-two hundred and three thousand oscillations per minute.

The primary effect of thus subjecting the grate to a high frequency and low amplitude vibration is to induce a very even spread of the fuel

throughout the entire grate area, and to subject the entire fuel body to a gradual and continuous advance toward the ash chute, the rapidity of such advance varying proportionately to the intensity of the grate vibration. Hence, by regulating the vibration intensity, the extent of the area of burning fuel on the grate may be increased or diminished. This regulation may be accomplished in various known ways, and preferably by a variation of the current strength energizing the magnet 22. Such a regulation lends itself admirably to a remote control, and particularly of a thermostatic type.

Inclination of the grate is not definitely essential to utilization of a high frequency vibration for gradually advancing the fuel bed, but inclination of the grate at a gradual pitch will expedite the fuel advance and hence reduce the energy employed to induce vibration.

Numerous advantages accrue from inducing the fuel advance by a continuous high frequency vibration, as described, as to some extent known in the prior art. High frequency vibration induces a fuel bed travel without detrimental, relative, disturbance of the fuel particles. Such a result has to some extent been heretofore secured by the use of chain grates, but not by bodily agitation of a grate member. Such slight relative disturbance of the fuel particles as is produced by operation of the described stoker prevents formation of blow holes and tends to immediately close such holes without breaking up or cracking of the fuel bed.

A highly desirable advantage of inducing fuel advance by high frequency vibration is the production of a substantially constant fuel depth throughout the area of combustion. The continued low amplitude agitation of the fuel particles tends to constantly and evenly fill any low areas of the fuel bed, and permits the particles to maintain a loose but substantially uniform mutual contact, as the combustion gases are driven off and the volume of the fuel bed decreases accordingly. This tends to eliminate clinker formation and maintain a substantially uniform and relatively low fuel resistance to the upward passage of air discharging from the tuyere vents.

The very rapid, low amplitude, vibratory movement imposed upon the fuel particles, in the described operation of the grate, creates and positively maintains a loose and uniformly expanded condition of the fuel such as permits a free ascent and thorough distribution of air and the ready escape of combustion gases, this movement furthermore gives rise to constant collisions between the particles so that they may not accumulate ash. In deriving these advantages, the described stoker very essentially differs from those which effect a gradual fuel feed by bumping or jarring a grate between intervals of rest. The particles are packed more closely together by such bumping or jarring, inducing coalescence of the incandescent particles, and resisting air rise and escape of gases. The present method strongly opposes coalescence and hence largely secures individual and consequently thorough combustion of the particles.

The employment of high frequency vibration lends itself particularly to installation of the described stoker as a replacement unit, or to any installation in which it is required that the fuel be fed to the grate through an opening (such as that of a clinker or ash door opening) having a width considerably less than that of the grate proper. This is for the reason that the high frequency vibration is immediately effective to spread the fuel laterally as well as longitudinally of the grate, so as to evenly cover the full area of the latter, after having been fed through the relatively narrow feed extension from the forward grate extremity.

Heretofore, it has been found quite difficult to effect satisfactory combustion of certain relatively fine grades of coal, known as Barley coal and #4 Buckwheat, etcetera. Such grades of fuel, which are far less costly than more commonly used large-sized grades, may be efficiently and economically burned by the herein-described stoker. The efficiency of combustion achieved by said stoker is, in fact, so high that it will make satisfactory use of certain grades of very fine fuel that have heretofore been considered waste products.

Utilization of grate agitation to advance a fuel bed and promote fuel combustion and to further induce a gradual flow of ashes down an inclined chute carried by the grate is believed a feature involving high originality, and it is further believed a distinctly novel feature to maintain an automatic feed of fuel to a grate from a point exterior to the furnace equipped with such grate, responsive to agitation of the grate.

While an electro-magnetic type of vibration actuator is described and shown and believed preferable, it may be noted that the high frequency and low amplitude distinguishing the grate vibration induced by the present invention is obtainable through various other mechanisms.

It is apparent that the magnetic force exercised is proportionate to the strength of the magnetizing electric current, and that this is susceptible to ready and inexpensive regulation. It is further evident that by varying the magnetizing current strength the grate oscillations may be correspondingly varied as to their intensity, and the rate of fuel advance upon the grate may be accurately regulated.

The term "grate" as employed throughout this specification and in the following claims is intended to designate any member providing an extended surface for carrying solid fuel and promoting combustion thereof, whether or not said member has openings either for an upflow of air or a downward discharge of ashes.

While it is apparent that the illustrated embodiment of my invention is well calculated to adequately fulfill the objects and advantages primarily stated, it is to be understood that the invention is susceptible to variation, modification and change within the spirit and scope of the subjoined claims.

What I claim is:

1. In a stoker, an approximately horizontal elongated support, a normally inclined grate secured upon one end portion of said support and movable with said support as a unit, means engaging the other end portion of said support pivoting the support to turn about an axis substantially transverse to its length, and means for holding said support selectively pivotally adjusted, to regulate the grate inclination.

2. In a furnace, an inclined grate, a furnace wall surrounding said grate, means for delivering fuel to the upper portion of said grate, a support carrying said grate and extending through the furnace wall, a pair of trunnions carrying said support, exteriorly of said wall, a pair of standards journaling said trunnions and mounted independently of the furnace, and means reacting between said trunnions and standards for holding

ing said trunnions selectively pivotally adjusted.

3. A stoker comprising a grate, means for delivering fuel to an end portion of said grate, and means for electro-magnetically vibrating said grate.

4. A stoker comprising a grate, a spring member, means imposing the full load of the grate on said spring member, and means for periodically flexing said spring member to vibrate the grate.

5. A stoker comprising a grate, a bar spring, means rigidly attaching said grate to the midportion of said spring, means rigidly supporting the ends of said spring, and means for periodically flexing said spring to vibrate the grate.

6. A stoker comprising a bar spring, a grate at one side of said spring, means rigidly attaching said grate to said spring, and means at the other side of said spring for periodically flexing the spring to vibrate the grate.

7. A stoker comprising a grate, means for delivering fuel upon said grate, supporting means for the grate, affording it a limited vibratory movement, an armature connected to the grate, and an electromagnet acting upon said armature to vibrate the grate.

8. A stoker comprising an inclined grate, means for delivering fuel to said grate, means for vibrating said grate to induce a travel of fuel down the incline thereof, a common support for said grate and vibrating means, and means for adjusting said support to vary the inclination of said grate.

9. A stoker comprising an inclined grate, means for delivering fuel to said grate, an actuator for vibrating said grate, means pivoting said grate and actuator to turn as a unit about a common axis transverse to the grate inclination, for varying such inclination, and means for holding said unit selectively pivotally adjusted.

10. A stoker comprising a grate, an inclined ash chute carried by said grate at one end thereof, at a level permitting a discharge of ashes from said grate to said chute, means for delivering fuel upon the grate adjacent to its other end, and means for agitating the grate and chute as a unit to effect a travel of fuel and ashes toward said chute and to advance ashes in said chute down the incline thereof.

11. A stoker as set forth in claim 10, said ash chute being inclined transversely to the direction of fuel and ash travel upon the grate.

12. The method of burning the finer grades of fuel consisting in effecting combustion of fuel upon a grate and continuously delivering additional fuel to said grate, and gradually and continuously withdrawing the fuel, in the course of its combustion, from the point of delivery, while continuously maintaining the fuel particles in rapid relative motion.

13. In a stoker, the combination with a furnace having an opening in a wall thereof, of an arm extending through and movable in said opening, a grate carried by said arm within the furnace, a bar spring disposed transversely to said arm exteriorly of the furnace, means securing said arm upon the midportion of said spring, spaced supports for the ends of said spring, and means for periodically flexing said spring.

14. In a stoker, the combination with a grate, of a bar spring extending substantially transversely to the grate, means for supporting the grate upon the midportion of said spring, a pair of spaced supports engaging the end portions of said spring and restraining said portions from flexure, and means for periodically flexing the

midportion of said spring to reciprocate the grate.

15. In a stoker, the combination with a grate, inclined from end to end thereof, of means for reciprocating said grate in a direction acutely angular to its length, and means for selectively varying the inclination of said grate, while maintaining the angularity of reciprocation to the grate length.

16. In a stoker, the combination with a grate pivoted to turn about an axis and disposed substantially at one side of said axis, of an actuator for vibrating said grate mounted to turn in unison with the grate about said axis and disposed substantially at the other side of said axis.

17. In a stoker, the combination with a grate, of an arm surmounted by said grate and extending downwardly from the grate at an acute angle thereto, means pivoting said arm to turn about a substantially horizontal axis transverse to the grate, and means for reciprocating said arm to vibrate the grate.

18. In a stoker, the combination with a grate inclined from end to end thereof, of means pivoting said grate to turn about a substantially horizontal axis, relatively close to one end of the grate, and means for vibrating the grate to and from said axis.

19. In a stoker, the combination with a grate inclined from end to end thereof, of a bar spring extending transversely of said grate, means for supporting the grate upon the midportion of said spring, a pair of trunnions carried by the ends of said spring, bearings journaling said trunnions, means for holding said trunnions selectively rotatively adjusted in said bearings to vary the inclination of said grate, and means for periodically flexing the midportion of said spring.

20. A stoker as set forth in claim 19, said flexing means being jointly carried by said trunnions for pivotal movement in unison with the grate.

21. In a stoker, the combination with a grate inclined from end to end thereof, of a flexible member, means fully supporting the grate upon said flexible member, means for periodically flexing the flexible member to vibrate the grate, and means for rotatively adjusting the flexible member about an axis substantially transverse to its direction of flexure, to vary the grate inclination.

22. A stoker comprising a grate, means for delivering fuel upon said grate, an inclined ash chute carried by the grate at a level permitting the discharge of ashes from the grate to said chute, and means for agitating the grate and chute as a unit to effect an advance of fuel and ashes toward said chute and to advance ashes in the chute, down the incline thereof.

23. In a stoker, the combination with a grate and means for delivering fuel upon an end portion of said grate, of means for agitating the grate to effect an advance of the fuel from said delivery means, and means carried by the grate in proximity to but independently of said fuel delivery means for regulating the depth of fuel distribution upon the grate.

24. In a stoker, the combination with a grate having fuel-retaining side walls and means for delivering fuel upon an end portion of said grate, means for agitating the grate to effect an advance of the fuel from said delivery means, opposed guides carried by said side walls adjacent to the fuel delivery means, and a gate adjustable in said guides to and from the fuel supporting face of the grate for regulating the depth of fuel distribution upon the grate.

25. In a stoker, a grate having a fuel feed extension of lesser width than the grate proper, means for delivering fuel upon said extension, means for agitating the grate to effect an advance of fuel from said extension to the grate proper and a distribution of fuel upon the grate proper, and means supported by the grate adjacent to the extension for distributing and regulating the depth of fuel on the grate proper.

26. In a stoker, the combination with a grate and means for delivering fuel upon an end portion of said grate, of means for agitating the grate to effect an advance of fuel from said delivery means, and a gate mounted on and extending across the grate in proximity to said delivery means, adjustable to and from the fuel supporting surface of the grate to regulate the depth of fuel distribution upon the grate.

27. In a stoker, the combination with a grate and a mounting affording the grate a vibratory movement, of an actuator for vibrating the grate comprising an electromagnet and coacting armature, one thereof being attached to the grate and the other fixed with relation to the grate, and means for varying the coacting relation of said magnet and armature.

28. In a mechanical stoker, the combination with a grate, reciprocatory in the approximate direction of its length, means for applying to said grate periodic forces, urging it to one limit of its reciprocation, and a spring tending to establish the grate in a mid position of its reciprocation, and flexed in one direction of such reciprocation by said forces, and effective, in the intervals between said forces, through counterflexure, to establish the other limiting position of grate reciprocation.

29. A mechanical stoker as set forth in claim 28, said spring fully supporting the grate.

30. In a stoker, an inclined grate, means for delivering fuel upon the upper portion of said grate, a pivotal support for the grate, means for securing the grate in selective pivotal positions on said support, and a motor for agitating the grate having an operative relation to the grate unvaried by pivotal adjustment of the grate.

31. In a stoker, an inclined grate, means for delivering fuel upon the upper portion of said grate, means pivoting the grate to turn about an axis substantially transverse to its inclination, whereby such inclination may be varied, means for positively retaining the grate selectively pivotally adjusted, and means for reciprocating the grate in the general direction of its inclination, while maintaining such inclination fixed.

32. In a furnace, an inclined grate, a furnace wall surrounding said grate, means for delivering fuel to the upper portion of said grate, an arm rigidly carrying the grate and extending exteriorly of said wall, a support for said arm, exterior to said wall, means pivotally mounting said arm on said support, to turn about a substantially horizontal axis, whereby the grate inclination may be varied; and means exterior to said wall for securing said arm in selective positions of pivotal adjustment.

33. A stoker comprising an elongated member, a grate superposed on one end portion of said

member, a spring support for said member, engaging the other end portion thereof, and a motor effective upon the last mentioned end portion of said member and coacting with said spring to effect rapid vibration of the grate.

34. A stoker comprising a pair of spaced coaxial trunnions, a pair of standards journaling said trunnions, a substantially U-shaped frame carried by and rigidly connecting said trunnions, a grate mounted on said trunnions and adapted for vibrating actuation, and a motor carried by and within said frame and operatively connected to the grate for vibrating said grate.

35. In a stoker, the combination with a furnace having an opening in a wall thereof, of a support extending through and movable in said opening, a grate rigidly carried by said support within the furnace, and a vibratory motor acting on said support exteriorly of the furnace for vibrating the grate.

36. In a stoker, the combination with a furnace having an opening in a wall thereof, of a support extending through and movable in said opening, a grate rigidly carried by said support within the furnace, a bar spring carrying said support exteriorly of the furnace, and means for periodically flexing said spring to vibrate the grate.

37. A stoker comprising a grate, a resilient support, means imposing the full weight of the grate on said support, and thereby adapting the grate for vibratory actuation, and a motor connected to said means for subjecting it and the grate to high-speed vibration.

38. The method of burning fuel in the form of small particles, consisting in forming a bed of such fuel, continuously supplying fuel to said bed, continuously vibrating said bed at a rate exceeding three hundred oscillations per minute and in a direction inducing travel of said bed, in its entirety, from the source of fuel supply, and maintaining by such vibration a loose, fluid-like, condition of the bed, permitting ready access of air to the particles, and resisting their cohesion, and continuously delivering air upwardly through the bed at numerous points thereof.

39. The method of maintaining a bed of fuel particles and effecting its combustion consisting in continuously vibrating said bed, as a whole, in a direction having a major component tending to advance the bed in a desired direction, and having a minor upward component, and at a rate of speed tending to continuously loosen the entire bed and to maintain a levitation of its particles, continuously delivering air upwardly through the bed, and continuously supplying fuel to the bed at its end from which the fuel is advanced.

40. In a grate replacement installation for furnaces, the combination with a main support and means for anchoring such support to the floor of a furnace room, of a replacement grate, a support for such grate extending from the main support and elongated to permit location of the main support and grate respectively exterior and interior to a furnace, and means carried by the main support and effective on the grate through the grate support to agitate the grate.

EDGAR O. MARTY.